PATENT SPECIFICATION

805,721

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International Classification:—H02l.

COMPLETE SPECIFICATION

Improvements in or relating to Three-phase Magnetic Circuits

We, COMPAGNIE GENERALE D'ELECTRICITE, a French body corporate, of 54, Rue la Boetie, Paris 8e, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention relates to three-phase magnetic circuits and is more particularly, but not exclusively, concerned with three-phase magnetic circuits for electric induction devices such as transformers utilising magnetic laminations having oriented crystals.

It has already been proposed to employ forms of magnetic circuits having the three parallel cores disposed at 120°, about a central part and interconnected by star-shaped or triangular yokes.

Of the various types of magnetic circuits having triangular yokes, use is frequently made, for example, of the type comprising three single-phase circuits linked together to form the complete three-phase circuit.

However, this form of construction has serious disadvantages because, as a result of the impossibility of ready exchange of the fluxes in the cores, and in the yokes of the component single-phase circuits, an increase in the flux is produced with a considerable increase in the losses. In addition, the proportion of third harmonics in the no-load current is very high.

The invention has for its object to propose three-phase magnetic circuits which are not attended by these disadvantages and concerns more especially the construction of magnetic circuits in which the flux exchange surfaces between the parts constituting the core and the yoke are large with minimum reluctance.

Accordingly, the present invention provides a three-phase magnetic circuit comprising three parallel cores interconnected by two triangular yokes so that the cores meet the yokes at the corners of the triangles, the said cores and yokes being formed of stacked and interleaved laminations, wherein each core consists of two separate bundles of laminations which form between them a dihedral angle, one of which bundles is connected to a bundle from one of the other two cores and the other of which bundles is connected to a bundle from the remaining core, the connections forming the yokes, so that the assembly consisting of the three cores thus connected and of the yokes by which they are connected forms three substantially rectangular frames, each frame having its upper and lower yoke portions imbricated by one or more laminations with the yoke portions of the other two frames.

For a better understanding of the invention and to show how the same may be carried into effect reference will now be made to the accompanying drawings in which:—

Figures 1 to 3 are views in perspective and to the same scale, showing the method of interleaving the elementary laminations of a magnetic circuit of the invention,

Figure 4 is a sectional view of a core of the magnetic circuit to an enlarged scale,

Figure 5 is a view in perspective showing the coil windings disposed on the cores (formed from said laminations) of a three-phase magnetic circuit,

Figure 6 is a view in perspective to an enlarged scale showing the interleaving of the laminations within a core, and

Figure 7 is a view in perspective of a three-phase magnetic circuit having laminations of a different form.

Figures 1 to 3 show the way in which the cores and yoke arms are formed from an assembly of a number of series of three laminations. Figure 1 shows a first series of three laminations 1, 2 and 3 each of

which is bent over at 90°. The first series is arranged to form a triangular magnetic circuit with a second series of three laminations 4, 5 and 6 which latter laminations are disposed on the first laminations and across them. For example lamination 6 crosses over lamination 3, and overlies the terminal portion of the yoke arm of lamination 2 as is shown at 11. This imbricated arrangement of the laminations forms a substantially equilateral triangle. The flux exchange regions between the parts constituting the core and the yoke are shown at 7, 8 and 9. The terminal portions of the yoke laminations overlap at 10, 11 and 12 and thus form joints having a double overlap. The lamination 13 which forms part of a third series of three laminations is disposed on the lamination 7 parallel to the lamination 1. Since the laminations are bent over with a small radius of curvature, the length of the bent over part is small. Consequently the bending may be effected after the annealing of the laminations without any substantial increase in the total losses of the circuit.

The annealing will therefore be effected on the flat laminations, which is more desirable. Nevertheless, it is always possible to effect an annealing after the bending of the laminations.

The laminations which are bent over from a core, to form each yoke will be referred to hereinafter as a bundle of laminations. Thus a core is formed from two bundles of laminations.

More series of laminations which are not shown in Figure 3 will be added to the three series illustrated, and they will preferably be disposed to form the yokes in such manner that the laminations of one bundle alternate regularly with the laminations of another bundle. However, the laminations could also be differently disposed provided that they are interleaved, that is to say that, in the yokes at least two laminations from each bundle have disposed between them more than one lamination from the other bundle.

One arrangement of the core is illustrated in Figure 4, and consists of two bundles of laminations separated by an insulating plate 23 which extends lengthwise of the core between the bundles. Each bundle consists of a group of large laminations 24 and groups of progressively small laminations 25. The inner edges of the laminations 24 and the inner corners of the smaller groups 25 bear against the insulating plate 23. A further insulating member 26 also extends lengthwise of the core and is made preferably of wood. The plate 23 and member 26 serve to locate and secure the laminations within the core. The dihedral angle formed between the laminations of each bundle is obtuse and its opening is directed towards the centre of the assembled circuit.

A number of methods of constructing the three-phase magnetic circuit of the invention are possible. Figures 5, 6 and 7 illustrating three of these methods by way of example.

Figure 5 shows the assembly of a three-phase magnetic circuit with the aid of laminations bent over in the form of an L. The laminations of the lowermost yokes as seen in Fig. 5 are first interleaved to form said yokes. The coils 14, 15 and 16 are thereafter placed on the cores thus formed and, as will be seen from Figure 5, the laminations intended to form the upper yokes project upwardly from the coils 14, 15 and 16. Said projecting end portions of the laminations are bent-over so the plane thereof lies in a plane which is transverse to the axis of the core. That is laminations 1, 2 and 3 are deformed as shown in Figure 5, and the remaining laminations are bent over, in turn, to form an arrangement of laminations similar to that shown in Figures 1 to 3. When all of the laminations have been so deformed the cores of each pair of coils are connected by two parallel yoke arms, one at each end of the coil, thereby completing the magnetic circuit between each pair of coils (a pair of coils being coils 14, 15 or 14 and 16, or 15 and 16).

Figure 6 shows an arrangement of a three-phase magnetic circuit with the aid of laminations previously bent over in U-form, wherein the bases of the U's form the yokes and the arms form the cores. The circuit is arranged with the laminations interleaved in the cores instead of in the yokes, and the upper laminations 27, 29 and 31 are interleaved with the lower laminations 28, 30 and 32. The arms of the U, which extend into the core are alternately of different lengths so as to allow for interleaving within the core. For example, the arm of lamination 27 is longer than that of lamination 29 (Fig. 6).

Figure 7 also illustrates the arrangement of a three-phase magnetic circuit with the aid of laminations previously bent over into the form of a U, but with interleaving in the yokes. Each core is separately assembled with the parts of the corresponding yokes. The windings are then directly wound on the cores. The three portions of the magnetic circuit are thereafter assembled by interleaving the yokes, that is to say, 17 with 18, 19 with 20 and 21 with 22 in the case of the upper yokes, and in the same manner in the case of the lower yokes. A three-phase magnetic circuit is finally obtained which is arranged in triangular form as shown in Figure 7.

The cores thus consist of two bundles of

laminations disposed parallel and surrounded by the coils of the windings. The laminations of the two bundles have a common edge which forms an air gap over the entire height of the core. In the case of the illustrated constructional forms, the laminations of two bundles of one core are disposed substantially at an angle of 120°.

In a magnetic circuit each lower and upper yoke takes the form of a triangle. In the case of the constructions illustrated, this triangle is equilateral, which has various known advantages, but the yokes may be arranged in any triangular form.

The flux exchange regions between the three cones of the magnetic circuit are disposed at the ends of each core at the points at which the laminations cross one another, that is to say, at the boundary of the cores and of the yokes. This arrangement has the advantage that it provides large flux exchange surfaces with low reluctance.

WHAT WE CLAIM IS:—

1. A three-phase magnetic circuit comprising three parallel cores interconnected by two triangular yokes so that the cores meet the yokes at the corners of the triangles, the said cross and yokes being formed of stacked and interleaved laminations, wherein each core consists of two separate bundles of laminations which form between them a dihedral angle, one of which bundles is connected to a bundle from one of the other two cores and the other of which bundles is connected to a bundle from the remaining core, the connections forming the yokes so that the assembly consisting of the three cores thus connected and of the yokes by which they are connected forms three substantially rectangular frames, each frame having its upper and lower yoke portions imbricated by one or more laminations with the yoke portions of the other two frames.

2. A magnetic circuit as claimed in claim 1, wherein the dihedral angle is an btuse angle and the opening thereof is directed towards the centres of said triangles.

3. A magnetic circuit as claimed in claim 1 or claim 2, wherein the bundles are held apart within the cores by means of an insulating element placed therebetween.

4. A magnetic circuit as claimed in any one of claims 1 to 3, wherein the laminations are bent over at the transition between core and yoke to form the corners of the magnetic circuit.

5. A magnetic circuit as claimed in claim 4, wherein each core comprises laminations which, after bending-over at one corner of the magnetic circuit, extend into the associated yokes to interleave with laminations from the other cores.

6. A magnetic circuit as claimed in claim 4, wherein each of the yokes comprises laminations which, after bending-over at one corner of the magnetic circuit, extend into the associated cores to interleave with laminations from the other yokes.

7. A magnetic circuit as claimed in claim 5 or claim 6, wherein each lamination is right-angled.

8. A magnetic circuit as claimed in claim 5 or claim 6, wherein each lamination is U-shaped.

9. A threephase magnetic circuit, substantially as hereinbefore described with reference to Figures 1 to 5, or Figure 6, or Figure 7 of the accompanying drawings.

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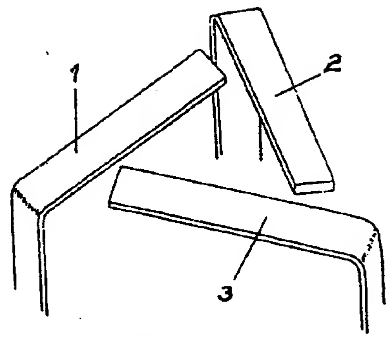

FIG. 1

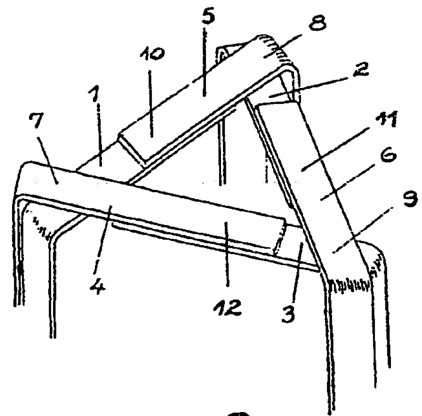

FIG. 2

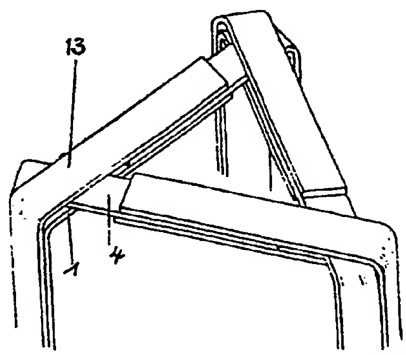

FIG. 3

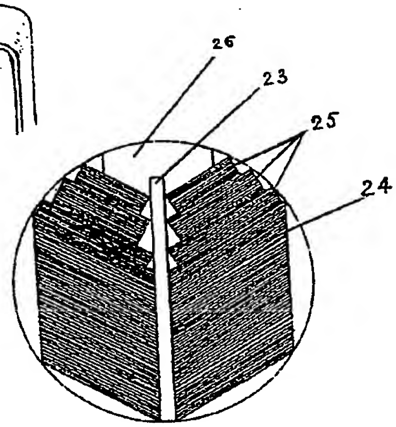

FIG. 4

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2 SHEETS

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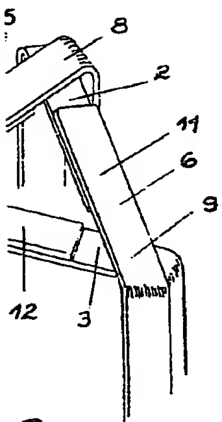
SHEETS 1 & 2



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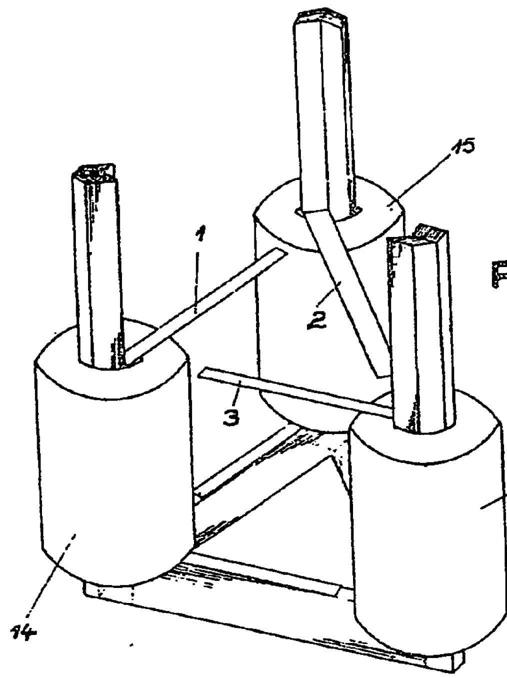
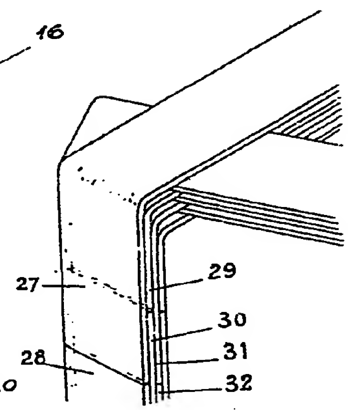


FIG. 5

FIG. 6



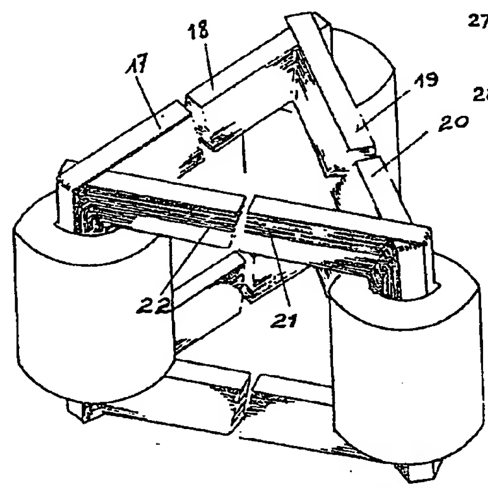
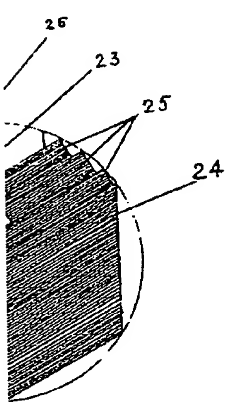


FIG. 7



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SHEETS 1 & 2

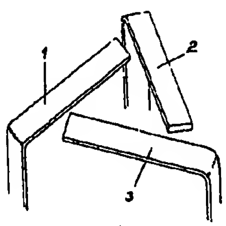


FIG. 1

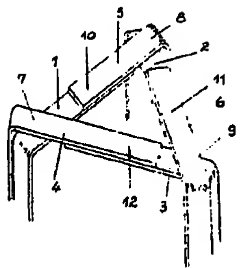


FIG. 2

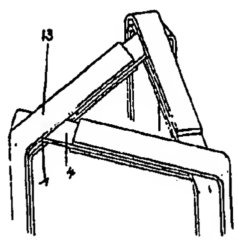


FIG. 3

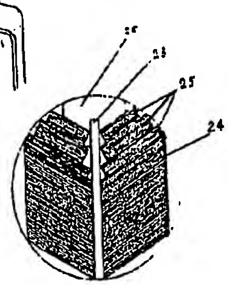


FIG. 4

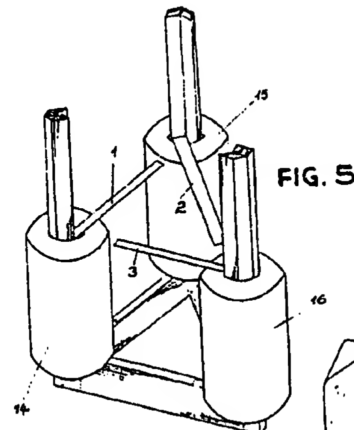
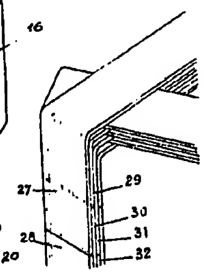


FIG. 5

FIG. 6



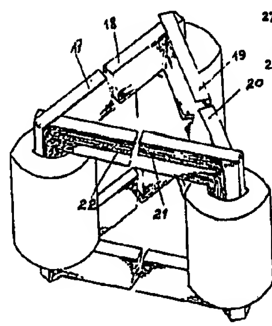


FIG. 7